

WHAT IS CLAIMED IS:

1. A driver circuit for driving a permanent-magnet electric motor, comprising:
an inverter for generating an electric current to be applied to the permanent-magnet motor, according to a commanded voltage value applied thereto;
a motor-drive-current detector operable to detect the drive current of the motor;
a current detector operable to detect a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current; and

a controller operable to calculate a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value, said controller being further operable to calculate a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage, said controller controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed.

2. A driver circuit according to claim 1, wherein said controller generates a value xd as said d-axis difference signal, and a value xq as said q-axis difference signal, the values xd and xq being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R - \omega L_d & -\omega L_q \\ \omega L_d & R - \omega L_q \end{pmatrix} \begin{pmatrix} j d \\ j q \end{pmatrix} + \begin{pmatrix} \omega L_d & 0 \\ 0 & \omega L_q \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$
$$\frac{d}{dt} \begin{pmatrix} j d \\ j q \end{pmatrix} = \begin{pmatrix} -\omega d & 0 \\ 0 & -\omega d \end{pmatrix} \begin{pmatrix} j d \\ j q \end{pmatrix} + \begin{pmatrix} \omega d & 0 \\ 0 & \omega d \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein id is said d-axis current,

iq is said q-axis current,

idr is said commanded d-axis current value,

iqr is said commanded q-axis current value,

v_d is a d-axis voltage applied to the motor,

v_q is a q-axis voltage applied to the motor,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor,

Φ is a number of magnetic cross fluxes of a permanent magnet of the motor,

j_d is a d-axis state quantity of said non-interference processor of said controller,

j_q is a q-axis state quantity of said non-interference processor of said controller,

and

ω_d is a coefficient.

3. A driver circuit according to claim 1, wherein said controller is operable for calculating said d-axis difference signal and said q-axis difference signal in a low frequency range, said controller controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed.

4. A driver circuit according to claim 3, wherein said controller generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,

i_{qr} is said commanded q-axis current value,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,
 R is an electric resistance of the motor, and
 ω is an angular velocity of a rotor of the motor.

5. A driver circuit for driving a permanent-magnet electric motor, by comprising:
an inverter for generating an electric current to be applied to the motor,
according to a commanded voltage value applied thereto;

a motor-drive-current detector operable to detect a drive current of the motor;

a current detector operable to detect a d-axis current and a q-axis current which
are respectively an exciting current component and a torque current component of the
detected drive current;

a current-difference calculator operable to calculate a d-axis current difference
between the detected d-axis current and a commanded d-axis current value, and a q-axis
current difference between the detected q-axis current and a commanded q-axis current
value;

a non-interference processor operable to calculate a d-axis difference signal
which is a function of a d-axis input voltage of the motor and is not a function of a q-
axis input voltage of the motor, and a q-axis difference signal which is a function of the
q-axis input voltage and is not a function of the d-axis input voltage; and

an inverter controller operable to control said inverter on the basis of the
calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference
signals are zeroed.

6. A driver circuit according to claim 5, wherein that said non-interference
processor generates a value x_d as said d-axis difference signal, and a value x_q as said q-
axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} xd \\ xq \end{pmatrix} = \begin{pmatrix} R - \omega d Ld & -\omega Lq \\ \omega Ld & R - \omega d Lq \end{pmatrix} \begin{pmatrix} jd \\ jq \end{pmatrix} + \begin{pmatrix} \omega d Ld & 0 \\ 0 & \omega d Lq \end{pmatrix} \begin{pmatrix} idr - id \\ iqr - iq \end{pmatrix}$$

$$\frac{d}{dt} \begin{pmatrix} jd \\ jq \end{pmatrix} = \begin{pmatrix} -\omega d & 0 \\ 0 & -\omega d \end{pmatrix} \begin{pmatrix} jd \\ jq \end{pmatrix} + \begin{pmatrix} \omega d & 0 \\ 0 & \omega d \end{pmatrix} \begin{pmatrix} idr - id \\ iqr - iq \end{pmatrix}$$

wherein id is said d-axis current,

iq is said q-axis current,

idr is said commanded d-axis current value,

iqr is said commanded q-axis current value,

vd is a d-axis voltage applied to the motor,

vq is a q-axis voltage applied to the motor,

Ld is an inductance of the d-axis of the motor,

Lq is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor,

Φ is a number of magnetic cross fluxes of the permanent magnet,

jd is a d-axis state quantity of said non-interference processor,

jq is a q-axis state quantity of said non-interference processor, and

ωd is a coefficient.

7. A driver circuit according to claim 6, wherein that said non-interference processor is operable on the basis of the calculated d-axis and q-axis current differences, for calculating said d-axis difference signal and said q-axis difference signal in a low frequency range.

8. A driver circuit according to claim 7, wherein that said non-interference processor generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value, i_{qr} is said commanded q-axis current value,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor .

9. A driver circuit for driving a permanent-magnet electric motor, comprising:

an inverter for generating an electric current to be applied to the permanent-magnet motor, according to a commanded voltage value applied thereto;

motor-drive-current detecting means for detecting the drive current of the motor;

current detecting means for detecting a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

current-difference calculating means for calculating a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

non-interference processing means for calculating a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-

axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage; and

inverter control means for controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed.

10. A method of controlling a driver circuit for driving an electric motor, characterized by comprising the steps of:

detecting a drive current of the motor;

detecting a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

calculating a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

calculating a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage; and

controlling an inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed.

11. A method according to claim 10, wherein said step of calculating a d-axis difference signal and a q-axis difference signal comprises calculating a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, according to the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R - \omega_d L_d & -\omega L_q \\ \omega L_d & R - \omega_d L_q \end{pmatrix} \begin{pmatrix} j d \\ j q \end{pmatrix} + \begin{pmatrix} \omega_d L_d & 0 \\ 0 & \omega_d L_q \end{pmatrix} \begin{pmatrix} i d r - i d \\ i q r - i q \end{pmatrix}$$

$$\frac{d}{dt} \begin{pmatrix} j d \\ j q \end{pmatrix} = \begin{pmatrix} -\omega_d & 0 \\ 0 & -\omega_d \end{pmatrix} \begin{pmatrix} j d \\ j q \end{pmatrix} + \begin{pmatrix} \omega_d & 0 \\ 0 & \omega_d \end{pmatrix} \begin{pmatrix} i d r - i d \\ i q r - i q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,

i_{qr} is said commanded q-axis current value,

v_d is a d-axis voltage (actually applied to the motor),

v_q is a q-axis voltage (actually applied to the motor),

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor,

Φ is a number of magnetic cross fluxes of the permanent magnet,

j_d is a d-axis state quantity of said non-interference processor,

j_q is a q-axis state quantity of said non-interference processor, and

ω_d is a coefficient.

12. A method according to claim 10, wherein said step of calculating a d-axis difference signal and a q-axis difference signal comprises calculating, on the basis of the calculated d-axis and q-axis current differences, said d-axis difference signal and said q-axis difference signal in a low frequency range.

13. A method according to claim 12, wherein said step of calculating a d-axis difference signal and a q-axis difference signal comprises calculating a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, according to the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,
 i_{qr} is said commanded q-axis current value,
 L_d is an inductance of the d-axis of the motor,
 L_q is an inductance of the q-axis of the motor,
 R is an electric resistance of the motor, and
 ω is an angular velocity of a rotor of the motor.